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Optical design of the laser injection line into a small-scale suspended interferometer for Quantum Noise reduction in GW detectors

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On 14 September 2015, a century after the birth of General Relativity, all the scientific and technological efforts for the experimental detection of gravitational waves (GWs) found a reward. The instruments that allowed the first direct detection are second-generation GW interferometers, such as LIGO and Virgo. At present, after the conclusion of the scientific observing run O3, about 90 GW events have been confirmed. The future challenges concern further technological improvements and the extension of the world-wide network of GW detectors. New techniques and strategies should be implemented for reducing any source of noise that inevitably falls into the measurements. Quantum noise (QN) is one of the major limiting contributions to the instrumental sensitivity of ground-based GW detectors, therefore techniques allowing a broadband QN reduction should be investigated before any possible integration in large-scale GW detectors. Currently, the technique adopted by the LIGO and Virgo collaborations consists of a frequency-independent squeezing (FIS) source coupled with a 300 m long detuned filter cavity, which produces in reflection frequency-dependent squeezing (FDS) to be injected from the dark port of the interferometer. Looking forward, especially in view of the third generation GW detectors such as ET, it is crucial to develop more compact FDS setups, such as the one based on the Einstein Podolsky Rosen (EPR) entanglement and on the ponderomotive squeezing. In particular, EPR-entangled states can be obtained by pumping an Optical Parametric Oscillator (OPO) cavity with a second harmonic detuned beam. A set up for testing EPR squeezed states into a small-scale suspended interferometer called SIPS (Suspended Interferometer for Ponderomotive Squeezing) is under implementation at the EGO R&D squeezing laboratory.
In this talk, a brief status of this experiment and the optical design of the laser injection path into SIPS will be illustrated. Particular attention will be given to describe the triangular input mode cleaner (IMC) cavity, a fundamental optical element ensuring that a Gaussian transverse intensity profile of the laser is sent into SIPS interferometer.

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